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The Use of Palatal Rugae in Assessment of Antero Posterior Tooth Movements

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Abstract: The present study was undertaken to determine the effect of orthodontic treatment on rugae pattern and to evaluate the validity and reliability of using palatal rugae area before, during and after orthodontic treatment to assess the degree of tooth movement. This study was a retrospective investigation in which patient records were evaluated at two different time periods. The sample consited of 60 treated cases from the Department of Orthodontics, K.V.G Dental College, Sullia. These included 30 cases from 2 different types of malocclusion- Angle's class I bimaxillary protrusion malocclusion and Angle's class I crowding malocclusion. During space closure the measurement from the study models showed that the mean incisor movement was 6.1, whereas, the mean molar movement observed was 4.9. The respective measurements obtained from the lateral cephalogram superimposition showed a mean incisor movement of 5.5 with SD 1.9 mm and the mean molar movement was 5.3. The amount of retraction in class I Bimaxillary protrusion sample ranged from 5.5mm in models and 5.7 mm in radiograph and in CI I Crowding it ranged around 4.5 mm in models and 4.6mm in radiographs.The amount of anchor loss in Class I Bimaxillary protrusion ranged from 5.8 mm in models and 5.5 mm in radiograph and in Class I Crowding it ranged around 5.9 mm for models and 5.9mm for the radiograph.

Keywords: Palatal rugae, tooth movements, stability

INTRODUCTION

Palatal rugae, also called plicae palatinae transversea or Rugae palatinae, refer to the ridges on the anterior part of the palatal mucosa. It is seen on either side of the median palatal raphe, behind the incisive papilla and are widely present in mammals.

There are approximately four rugae on each side of the palate. Slightly more rugae are found in male and on the left side in both genders. Generally, there is no bilaterally asymmetry in the number of primary rugae or in their angulation from the midline. The first (anterior) rugae contacts the median palatal raphe, while the rest have their origins lateral to it. Together with the teeth and the tongue, rugae take part in mastication by helping to sense, hold and mash the food. Rugae patterns have been studied for various purposes, published reports being mainly in the field of Anthropology, Comparative Anatomy, Genetics, forensic Odontology, Prosthodontics and orthodontics.

Tooth size arch length discrepancy (TSALD), one of the most common orthodontic problems is a discrepancy that occurs when the sum of the mesio-distal crown width of all the teeth exceeds the bony arch perimeter available. By far, the most common method of resolving substantial tooth size arch length discrepencies is to treat patients with extraction of premolars. The decision of embark on an extraction treatment strategy should be based on specific objectives for tooth movement. This leads to decision concerning incisor and molar position in the anteroposterior dimension together with the issue of arch length deficiency.

Placing teeth in the appropriate antero-posterior position is an essential aspect of any orthodontic case that involves space closure. But, not all of extraction space, however, is needed for this correction. Depending on the treatment objectives and anchorage requirements, this may involve distal movement of the anterior teeth, mesial movement of posterior teeth, or a combination of both. Also, it is an undeniable fact that, some of the extraction space will be lost during retraction of the anterior teeth because of the inadvertent mesial movement of posterior teeth that form the anchorage unit. Anteroposterior tooth movements during extraction space closure can be assessed by various means, of which the use of lateral cephalograms is the most common. Since its inception, cephalometrics, have advanced and is used widely in orthodontic practice and research institutions. Cephalometric superimpositions are the only reliable method to determine whether orthodontic space closure has been performed according to planed anchorage requirements. Some disadvantage of cephalometric radiographs like technique sensitivity, overlap of bilateral structures make it imperative occasionally to combine data derived from both cephalometric analysis and measurements on the dental models for the study of orthodontic treatment changes.

Another method for assessment of dental changes involves the use of dental study models. Dental plaster models are 3-dimensional records of malocclusion that have been used most successfully during diagnosis and treatment planning of orthodontic patients. However,their role in longitudinal studies of growth and development or the analysis of treatment change has been more limited. The superimposition of dental casts might be a useful method to study longitudinal dentoalveolar changes related to dentofacial growth or orthodontic therapy as it provide a distinct picture of structural changes that occurs during the process[1]. However the superimposition of dental casts requires stable references on the surface of the cast. The supposed uniqueness and overall stability of palatal rugae suggest their use for assessment of degree of tooth movement during orthodontic therapy. An area in which it is important to describe change during premolar extractions is the palate, especially the palatal rugae. Its importance lies, in the fact that, it may be used as a stable landmark for dental research.

Fig-1: Palatal Rugae

The present study was undertaken to determine the effect of orthodontic treatment on rugae pattern and to evaluate the validity and reliability of using palatal rugae area before, during and after orthodontic treatment to assess the degree of tooth movement.

Aims & Objectives

- To determine changes in the position of the incisors and molars, with respect to the palatal rugae as result of orthodontic treatment.
- To evaluate the validity and reliability of using palatal rugae area before, during and after orthodontic treatment to assess the degree of tooth movement.

MATERIALS AND METHOD

This study was a retrospective investigation in which patient records were evaluated at two different time periods.

The sample consited of 60 treated cases from the Department of Orthodontics, K.V.G Dental college, Sullia. These included 30 cases from 2 different types of malocclusion- Angle's class I bimaxillary protrusion malocclusion and Angle's class I crowding malocclusion. In the present study the following inclusion and exclusion criteria were followed.

Inclusion criteria

- Patients who underwent first premolar extraction as part of orthodontic treatment.
- Age range- 14-30 years.
- Patients with Angles class I malocclusion.

Exclusion criteria

- Patients who had undergone extraction of premolars before commencing orthodontic treatment, due to reasons other than orthodontic treatment.
- Inferior quality of cephalometric radiographs.
- Patients who underwent palatal expansion(RME or SME) or Orthognathic surgery.

The records consisted of pre-treatment and post-treatment maxillary study casts and lateral cephalometric radiographs from each subjects. Landmarks were identified on pre-treatment and post-treatment dental casts using a 0.3 mm mechanical lead acetate pencil. The pretreatment and post treatment casts were evaluated at the same time to aid in proper landmark identification. The study casts were then photographed using a 16 Mega pixel camera (NIKON COOL PIX L820) . This picture of the dental cast was digitized with a computerized system using the dHAL software.

Each cast was assessed for the magnification and it was found that magnification ranged from 0% to 3%. The computerized analysis program corrected for any magnification as each case was digitized.

The following procedures were undertaken on the study models

- Based on Lysell's[2] method the rugae were numbered from first to third with the first ruga being the most anterior.
- A line through incisive papilla anteriorly and posteriorly through fovea palatine was used to

construct a median reference line.

- Lines were constructed perpendicular to the median line through the mesial pit of the first molar and the corresponding ruga point on the right side and through the incisal edges of the right central incisor.
- A line was also constructed perpendicular to the median line through the incisal midpoint.
- Two other lines were constructed perpendicular to median reference line through the mesial pit of 2nd premolar and mesial pit of 2nd molar to assess the arch width changes that occur following treatment.
- The movement of the central incisor was arbitrarily measured relative to the right rugae point.

Landmarks considered were

- Anterior point of mid palatine raphe
- Posterior point of mid palatine raphe
- Medial point of third rugae
- Lateral point of third rugae
- Mesial pit of II bicuspid
- Mesial pit of II permanent molar
- Midpoint of line connecting point 5 & 6
- Most prominent point on permanent central incisor
- Point corresponding to mesial pit of Ist molar on the median reference plane.

Standard reference point

A-Line drawn perpendicular to mid palatine raphae through the medial point of third rugae of the side which is more reliable D-Line drawn perpendicular to mid palatine raphe through the mesial pit of permanent 1st molar.

Linear measurements considered were

a-Mesial point of third rugae to incisal edge of central incisor in pretreatment cast.
a^1-Medial point of third rugae to incisal edge of central incisor in post treatment cast.
b-Mesial point of third rugae to the line D in pretreatment cast
b^1-Medial point of third rugae to the line D in post treatment cast
E-Distance from point 7 to the mid palatine raphe.

The computer software was used to measure the following variables

- Maxillary incisor position relative to medial point if third ruga on the right side, the pretreatment and post treatmet casts.
- Maxillary first molar position right relative to the medial point of third ruga on the right side, on the pretreatment and post treatment casts.
- Incisor movement measured by substracting the posttreatment position from the pretreatment position relative to the third ruga medial point.
- Maxillary first molar movement measured by substracting the post treatment position from the pretreatment position relative to the third ruga medial point.

Each cephalometric radiograph was taken with the same cephalostat(Planmeca Proline XC with Dimax3 X ray apparatus) installed with Romexis software and each patient was positioned the same fixed distance from the x-ray source.

Pretreatment and post-treatment lateral cephalometric radiographs were traced on acetate paper by the investigator using a 0.3 mm mechanical lead pencil. The radiographs for each subject were traced at the same time to aid in the proper identification of structures. The tracing included the floor of the orbit, the hard palate the anterior and posterior images of the zygomatic process of the maxilla and the pterygomaxillary fissure. The maxillary central incisor and the maxillary first permanent molar were traced after the pretreatment and post-treatment tracing were superimposed.

Standard reference planes

1.Pterygoid vertical
2.Palatal plane
3.True horizontal drawn 7th to the Sella-Nasion plane

Landmarks considered

A-Point at which a perpendicular line from palatal plane contacts the incisal edges.
A1-Point at which a perpendicular line from palatal plane contacts the incisal edges after orthodontic space closure.
B-Point at which a perpendicular line from palatal plane contacts the most prominent point of mesial surface of molars after orthodontic space closure.

Linear measurements considered

A to PTV-incisor to pterygoid vertical (pretreatment)
A^1 to PTV-Upper incisor to pterygoid vertical (posttreatment)
B to PTV-Upper molar to pterygoid vertical (pretreatment)
B^1 to PTV-Upper molar to pterygoid vertical (post treatment)

The variable measurements on cephalometric radiographs are

- Maxillary incisor position relative to pterygoid vertical on the pretreatment and post treatment radiographs
- Maxillary first molar position realtive to pterygoid vertical, on the pretreatment and post treatment casts.
- Incisor movement measured by subtracting the posttreatment position from the pretreatment position relative to the third ruga medial poinr.
- Maxillary first molar movement measured bu

subtracting the posttreatment position from the pretreatment position relative to the third ruga medial point.

For the purpose of analysis, the data for male and female subject were considered because variations in the size, shape or configuration of the rugae were not relevant; it was necessary only that the same ruga landmarks are identified on the pretreatment and post-treatment dental casts for each subject.

Paired t test were performed to determine whether a significant difference existed between the measurements for the right and left sides. The null hypothesis was that the difference between the right and the left side variables was zero. Because there was no statistical difference between the right and left first molar variables, they were averaged.

The mean molar movement measured on the lateral cephalometric radiograph was compared with the mean molar movement measured relative to the rugae landmarks on the study casts. Paired t test were performed to assess whether a significant difference existed between the cephalometric variable and the study model variable was zero. Similarly, mean incisor movement measured on the lateral cephalogram was compared with the mean incisor movement measured relative to the ruga landmarks on the study casts. The correlation between the two values was also estimated to assess the degree of correlation between the cast and cephalometric variables.

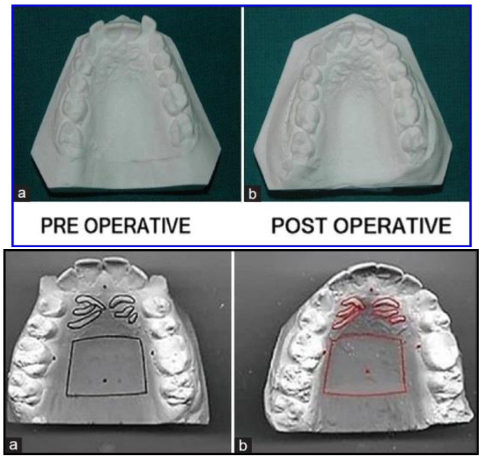

Fig-2,3: Casts showing pretreatment and posttreatreatment position of palatal rugae

STATISTICAL ANALYSIS

Descriptive statistics including mean, standard deviation and range will be calculated for the cast variables and cephalometric variables that described anterioposterior tooth movements.

Paired t test were performed to assess whether a significant difference existed between these variables. The null hypothesis was that the difference between the cephalometric variable and the study model variable was zero.

The correlation between the two values were also estimated to assess the degree of correlation between the cast and cephalometric variables.

RESULTS AND OBSERVATION

Table-1: Pretreatment and post-treatment values for the 2 groups

1. CLASS 1 BIMAX

	Age	PREC	POSTC	PREB	POSTB	PRE APTV	POST APTV	PRE BPTV	POST BPTV	CC	BB	APTV A^1PTV	BPTV B^1PTV
Mean	17.5	62.2	55.6	41.2	36.1	59.9	54.9	40.1	35.1	5.5	5.8	5.3	5.5
N	30	30	30	30	30	30	30	30	30	30	30	30	30
Sd	2.5	8.9	9.5	6.5	6.2	8.7	8.5	6.4	6.2	1.1	1.3	0.9	0.8

2. Class i crowding

	Age	PREC	POSTC	PREB	POSTB	PRE APTV	POST APTV	PRE BPTV	POST BPTV	CC	BB	APTV A^1PTV	BPTV B^1PTV
Mean	18.2	62.6	58.4	40.9	36.1	58.1	53.1	31.2	25.2	4.5	5.9	5.1	6.1
N	30	30	30	30	30	30	30	30	30	30	30	30	30
Sd	2.5	8.4	8.1	6.9	7.1	6.9	7.4	5.7	6.1	1.7	1.5	1.5	1.7

Table-2: Mean incisor and molar tooth movement values

Paired sample statistics	MEAN	N	Std.Deviation
CC	6.1	60	2.6
APTV-A^1PTV	5.5	60	1.9
BB	4.9	60	1.6
BPTV-B^1PTV	5.3	60	1.8

During space closure the measurement from the study models showed that the mean incisor movement was 6.1 with SD-2.6 mm, whereas, the mean molar movement observed was 4.9 with SD 1.6 mm. The respective measurements obtained from the lateral cephalogram superimposition showed a mean incisor movement of 5.5 with SD 1.9 mm and the mean molar movement was 5.3 SD 1.8mm. These values give us a picture that first premolar extraction spaces are used up roughly half and half by retraction and buccal segment advancement respectively and the measurement obtained from the study models are almost similar to measurements from the lateral cephalogram.

The amount of retraction in class I Bimaxillary protrusion sample ranged from 5.5mm in models and 5.7 mm in radiograph and in CI I Crowding it ranged around 4.5 mm in models and 4.6mm in radiographs.The amount of anchor loss in Class I Bimaxillary protrusion ranged from 5.8 mm in models and 5.5 mm in radiograph and in Class I Crowding it ranged around 5.9 mm for models and 5.9mm for the radiograph.

DISCUSSION

In the present study a sample of 60 patients with 30 each of pretreatment Class I crowding and class I bimaxillary protrusion were selected for the study. In all cases, four first premolars were extracted. During space closure the measurement from the study models showed that the mean incisor movement was 6.1 with SD- 2.6 mm, whereas, the mean molar movement observed was 4.9 with SD 1.6 mm. The respective measurements obtained from the lateral cephalogram superimposition showed a mean incisor movement of 5.5 with SD 1.9 mm and the mean molar movement was 5.3 SD 1.8mm. These values give us a picture that first premolar extraction spaces are used up roughly half and half by retraction and buccal segment advancement respectively and the measurement obtained from the study models are almost similar to measurements from the lateral cephalogram.

The use of palatal rugae as a built in yard stick to record mesiodistal changes in tooth position post orthodontic treatment, has been attempted in this study. Studies that have evaluated the stability of medial ruga points have found that medial ends of third rugae are stable landmarks. These studies evaluated only the changes between the rugae; in other words, the relationship of the ruga to the teeth was not assessed. However, investigators have subsequently applied these findings, and used these landmarks when evaluating tooth movements. Some investigators have found that the lateral ends of the rugae are unstable[3-8].

Peavy and Kendrick[4] reported that the lateral ends of the rugae were affected by the movement of the teeth. However, they evaluated the movement of canines and second premolars and did not evaluate molar movement. Van der Linden[5] reported that the first molar moved mesially relative to the lateral end of the third ruga. His study was based on observations over a 10-year period, until the subjects were 16 years old. The rate of mesial movement was approximately 0.4 mm per year during the period of time, starting when the premolars were completely erupted and ending when the subject was 16 year old. However, Van der Linden[5] evaluated non orthodontivally treated individuals. If there is a tendency for the molars to move mesially relative to lateral ruga points, this tendency may be inconsequential when compared with molar movement when first premolars are extracted.

On the other hand, Bailey *et al.* [7] found that all of the medial and lateral ends of the first 3 palatal rugae were stable when patients were treated with no extraction of teeth. They also found that the lateral ends of the third palatal ruga were stable in patients with both extraction and no extraction.

Results published by Williams and Hosila [9] states that 67% of the space was taken by retracted segments using the Begg technique with no headgear. Similarly, Creekmore[10] states that two-thirds of the extraction space could be used for retraction and the correction of crowding and only one third would be used by the buccal segments. Overall, previous studies [11,12]have generally shown more maxillary anterior retraction which is similar to the results that were observed in this current study since all of these studies were including class II patients in their sample and not just class I patients.

Analysis was limited to changes in the maxilla where the medial endpoints of the third pair of palatal rugae can be used as fiducial landmarks against which tooth movements can be qualified[4-8]. The mean molar movement relative to the medial ends of the third ruga was not statistically significant from the mean molar movement measured cephalometrically. Also, the mean incisor movement relative to the medial end of the third palatal rugae and the mean incisor movement measured cephalometrically were not statistically significant. Combining these results suggests that the medial end of the third palatal ruga is a suitable reference point for the assessment of molar and incisor movement.

These findings differ somewhat from previous studies that have attempted to evaluate the stability of the palatal rugae. Hence following the study by Hoggan & Sadowsky[8] that concludes that the medial ends of third palatal rugae for the assessment of antero-posterior tooth movements, it was crucial that the current investigation determine whether the medial points of the third ruga could be reliably used to assess tooth movements. The findings of the present investigation do, in fact, support the use of these landmarks for that purpose.

The present study also assessed the correlation between the different tooth movements in the study models and cephalogram. A 2-tailed Pearson correlation analysis revealed a correlation between the incisor tooth movements which was significant at 0.01 level. A similar test was performed for the molar tooth movements which were again significant at 0.01 level. These findings were similar to the findings as stated by Hoggan and Sadowsky[8] who evaluated the use of palatal rugae as reference points for the measurement of tooth movement, in a manner comparable with cephalometric superimpositions on a sample of 33 patients. In the present study, an even larger sample size of 60 was used. The findings from the present study also corroborates the fact that the medial end of third palatal rugae is a stable landmark as concluded by earlier authors. These findings also support the fact the medial end of third palatal rugae can used for the superimposition of progressive dental casts.

Hauser *et al*,[13] used photographs of the dental casts for analyzing the rugae. This method was appropriate for describing and classifying rugae but would be unacceptable for measuring distances. This method by Hauser was used for the present study. Landmarks were identified on pretreatment and post-treatment casts were evaluated at the same time to aid in proper landmark identification. Each study model pretreatment and post treatment was photographed with a 7.1 Mega Pixel 15x zoom digital camera in the micro mode for reducing any vertical distance errors.

Also, the method that was used in the present study allowed for optimal visualization & measurement of all dental cast landmarks. When structures are measured at different vertical levels, this method would introduce significant error. The amount of magnification error was determined by capturing two subsequent photographs of each study model with a millimeter ruler at the occlusal level and the palatal vault level. Based on the classification method of Lysell[2], the rugae were numbered from first to third, with the first rugae being the most anterior. A line through anterior raphe point and posterior raphe point were used to construct a median reference line. The movement of the central incisor was arbitrarily measured relative to the right ruga point.

A segment of a millimeter ruler was placed on the occlusal surface of 2nd premolar and other ruler at the palatal vault of the study cast, at the level of the third palatal ruga. This cast was photographed and loaded into the software. The image of the ruler was assessed for magnification at the depth of the palatal vault a magnification of 5% was measured whereas at the occlusal level it ranged from 0% to 3%. It was assumed therefore that the magnification of each scanned image of a study model ranged from approximately 0% at the level of the cusp tips to 5% at the depth of the palatal vault. Given that the magnification error was different depending on the vertical point at which a measurement was made, it was decided that the computer analysis program would correct for the magnification at the level of the occlusal plane as each case was digitized. The images of the models that were saved and loaded on dHAL software, a freeware had an overall magnification error of 0% to 5% which was corrected by same software [14-17].

Furthermore, in this present study the method of assessment of dental study models was very simplistic and reliable. This method of studying casts uses equipment that is becoming commonplace in many homes and offices: a computer with a scanner, printer, and associated software. In other words, this technique for analyzing study casts could be easily implemented by many investigators and clinicians. This technique is not particularly time consuming and does not require any particular expertise.

CONCLUSIONS

In the present study, changes in the anteroposterior position of the maxillary incisors and maxillary molars with reference to the medial end of the third palatal rugae as a stable landmark were investigated in patients who underwent maxillary first premolar extraction. The magnitude of tooth movement during extraction space closure was used to determine how the space gained by extraction of four first premolars is used by the orthodontist in resolving patient's malocclusion.

The conclusions

- First premolar extraction spaces were used up roughly half and half and half by retraction and buccal segment advancement respectively.
- The mean molar movement relative to the medial ends of the third ruga was not statistically significant from the values measured cephalometric ally. Also, the mean incisor movement relative to the medial end of the third palatal rugae and the values measured cephalometric ally were not statistically significant which indicates that the measurements obtained from the lateral cephalogram. Thus, antero-posterior molar and incisor movement may be assessed as accurately with dental casts as with maxillary cephalometric superimpositions.
- The results also suggest that the medial end of the third palatal ruga is a suitable reference point for assessment of molar and incisor movement. Findings also support the fact that medial end of third palatal rugae can used for the superimposition of progressive dental casts.

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